

# MULTILAYER COATING CONCEPTS: IS IT TIME FOR A NEW APPROACH?

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*In today's fine paper environment we now believe it can make more sense to use the functionality of kaolin in precoating rather than in topcoating.*

*Modest amounts of kaolin combined with coarse carbonates in precoating can improve quality and give more degrees of freedom for reformulating the topcoat to lower overall cost.*

## WHERE TO START

Selecting kaolins that are relatively coarse in particle size, with high aspect ratios and hence large plate diameters, are key to making this approach successful. Although kaolins from North America and Brazil are currently used in these formulations, there are select reserves in Asia which could, with the appropriate processing and know how, provide the necessary characteristics for successful precoating applications.

Good basepaper coverage is essential in maintaining quality in multi-layer coating applications and can also offer potential for cost reduction. For example improved coverage could enable the use of lower cost rougher base stocks without the same tendency for mottle related issues. Additionally, improved precoat coverage can facilitate the use of kaolin free topcoats especially on rougher basestocks. This can bring value through replacing high cost ultrafine glossing kaolin with lower cost precoating kaolin. Further savings can then be made with respect to binder type and level in the topcoat recipe.

Using coarse platey kaolin in the precoat can improve the smoothness and delta gloss of matt or silk grades, with further benefits coming from using the same kaolin to replace some coarse ground calcium carbonate (GCC) in the top coat. This approach does not reduce the overall formulation cost for the coatings, but it can improve appearance.

## THE MULTILAYER COATING MODEL

Much of the coated wood-free paper produced globally is multi-coated with two or three coating layers applied to each side of the paper. The precoat and mid-coat layers provide physical coverage of the base and optical performance, while the top coat provides surface finish (gloss, silk, or matt) and printability.

The precoat in most coated fine paper applications today is based on 100% coarse, inexpensive carbonate while the topcoat is generally based on combinations of fine GCC and ultrafine glossing kaolin. However, in many regions, including much of Asia, topcoat kaolin is significantly more expensive than standard fine carbonates. So the trend among large mills is to reduce or eliminate glossing kaolin in top coating.

Low-kaolin or kaolin-free top coating is well established. However, developing sheet gloss and print gloss remains a challenge and often requires significant reformulation in binders and additives. Porosity control and mottle also can be issues. Solving these problems can lead to increased formulation costs, which can offset the savings associated with fine kaolin reduction, and brand image can suffer if printability issues persist.

In many cases, the problems associated with low-kaolin top coating can be linked to base paper effects, unevenness in the coating layers, and porosity characteristics. Achieving good base paper coverage can resolve these issues. The best solution overall might be to focus on improving the precoat, rather than the top coat itself.

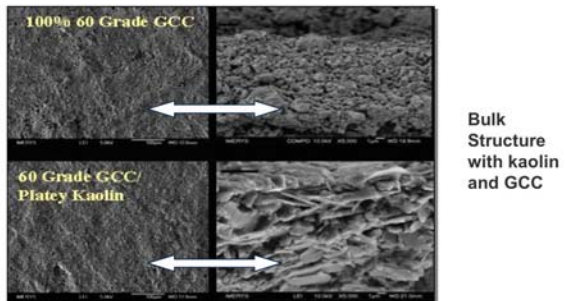
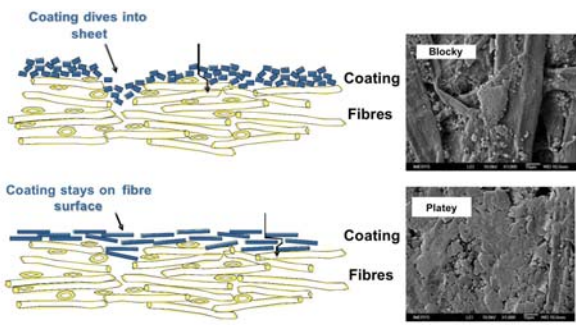
Historically, kaolin use in wood-free precoating has been low due to cost and brightness considerations, but the development of lower-cost, high-brightness platey kaolins is changing the dynamic. It may now make sense from a cost performance standpoint to use kaolin functionality in precoating rather than in top coating.

## PRECOATING INFLUENCES

Pigment selection for precoating markedly influences base paper coverage and the ability to provide a good barrier layer for top coat applications. 25 parts of high aspect ratio kaolin added to a precoat, combined with coarse GCC and a latex starch recipe have proven to be quite effective.



Example 01 Bulk and Coverage



Bulk Structure with kaolin and GCC

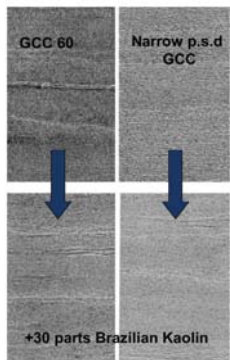
BASEPAPER COVERAGE AND SURFACE CHARACTERISTICS

On a repeat basis, studies have shown that adding kaolin to the precoat reduces precoat roughness. Through extensive analysis using test such as laser profilometry, which assesses roughness at different length scales, and the more classic burnout test, we have demonstrated significantly improved coverage through this approach. This has positive implications for the roughness, sheet gloss, print gloss development, and mottle characteristics in the finished paper. In addition the improved coverage can result in reduced fibre pick during coating, improving paper machine runnability and efficiency and reducing the need to increase binder in the formulation.

When combined with GCC, high aspect ratio kaolins can also deliver a bulky structure. This will further improve physical coverage and also optical coverage through increased light scattering which can be important on lower brightness basestocks (eg Board). However, the structure will retain a high degree of tortuosity, making fluid flow and migration of top coat binders more difficult.

Optical and coverage benefits of kaolin and GCC combinations have been evident in pilot scale studies of wood-free precoating. In the following example 30 parts of kaolin in the precoat show improvement in coverage when added to standard or engineered (steep) GCC in metered size press precoating, resulting in significantly improved smoothness. Kaolin addition to standard GCC typically has a minor effect on non-fluorescent brightness and increases opacity to a small degree going some towards achieving the level normally seen with engineered carbonates.

Example 02 Metered Size Press Precoating



Formulation	Solids (wt%)	B'ness (-UV)	Opacity	PPS (µm)
Coarse GCC (60)	70.8	85.2	85.6	6.0
Narrow p.s.d GCC (95)	65.6	85.9	86.6	5.7
70:30 Standard GCC/ Platey Kaolin	64.9	84.9	86.6	4.9
70:30 Narrow p.s.d. GCC/ Platey Kaolin	63.1	85.7	87.3	4.6

Pilot coating 1500 m/min, Latex/Starch recipe, 10 gsm

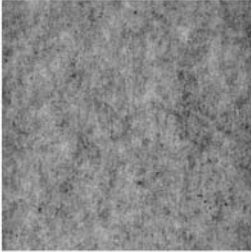
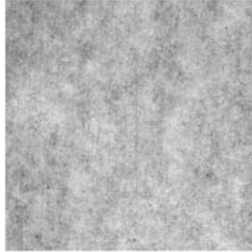
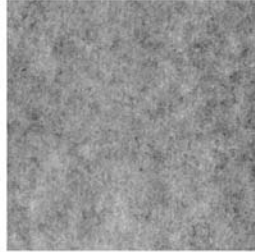
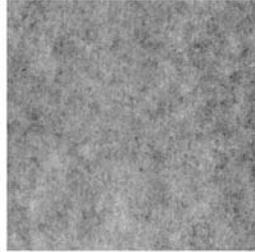
- Significant improvements in coverage and PPS from kaolin addition to precoat.
- Bulking effects of kaolin and standard GCC give light scatter and opacity benefits v standard GCC alone.
- Further benefits from kaolin and narrow p.s.d. GCC together.

The key to improved coverage and bulk in the precoat lies in the aspect ratio of the kaolin; with higher shape kaolins giving better structuring and performance than lower shape kaolins.

These effects were further explored in a pilot coating study which assessed a range of North American and Brazilian precoat kaolin options. These were used as low-level blend components with standard GCC in a blade-coated European wood-free application.

As before, coverage and smoothness improved compared to 100% GCC precoats when any of the kaolins were added to the recipe. More detailed analysis using scanning electron microscopy of paper cross-sections showed these benefits arose mainly from the increased bulk giving significant increased coating thickness. →

Optical scans of double coated boards (512x512 pixels at 0.1mm/pixel)

Precoat Topcoat	Coarse GCC Ultrafine GCC	Coarse GCC/Coarse Kaolin Ultrafine GCC	Coarse GCC Fine GCC/Ultrafine Kaolin
			
Gloss	47	50	48
PPS	1.47	1.38	1.47
Brightness	73.3	77.1	74.9
Mottle	0.068	0.052	0.056

- Using kaolin in the precoat improves gloss and brightness, makes the board smoother and reduces optical mottle.

### INFLUENCE OF PRECOAT IN GLOSSY WOOD-FREE

Paper and print gloss development remain the key challenges when using kaolin-free top coats in multilayer coating applications.

A 100% GCC top coat is often slightly deficient in sheet gloss and print gloss compared to more conventional recipes containing 20-30 parts of ultrafine kaolin. Increasing the sheet and print gloss in the kaolin-free systems can be challenging and can often mean changing to finer binders with lower ink interactivity and/ or increasing calendar load, which can be detrimental to opacity and stiffness.

Using high shape kaolins in the precoat can help change these dynamics. In numerous studies benefits to print gloss and opacity have been observed through this approach which gives more degrees of freedom for topcoat design.

In one case study, the topcoats based on 100 parts ultrafine GCC, were applied to a range of kaolin-containing precoats and a reference GCC-only precoat. Coatings were applied at 69% solids in the laboratory. The coated papers were then laboratory supercalendered to give gloss levels of close to 75 with the reference system. The results are shown in the following table and indicate benefits to print gloss when the kaolin free-topcoat was applied onto kaolin- containing precoats. In this study sheet gloss was not improved, through kaolin addition to the precoat, but it should be noted that the basepaper was already reasonably smooth with a PPS of 5.6. On rougher basestocks (eg white lined Board) 2-3 units improvement in sheet gloss have been observed through kaolin addition to the precoat.

Opacity was also improved which can be beneficial if harder calendering is required to restore gloss or for lighter weight applications where opacity can often be a critical parameter. Adding low levels of kaolin to the precoat tended to have relatively little effect on finished paper brightness after application of the top coat, partly because bulk structuring improves light scattering. This also has implications for opacity; kaolin addition in the precoat can allow more freedom for adjusting calendering to regain gloss.

Although non-UV brightness is largely unaffected by kaolin in the precoat, fluorescence can be reduced, resulting in lower overall UV brightness. This drop is more than offset by kaolin removal from the top coat and could be adjusted by changing the balance between optical brightening additives in pre- and top coat.

### Example 04 Technical Needs in Low Gloss Papers



- Producing a good matt or silk paper is really about finding the best compromise between often competing paper characteristics
- Achieving good print snap without slowing ink setting and achieving low sheet gloss with good smoothness and bulk are often key challenges in these applications
- Here we see how coarse platy kaolin in the precoat as well as the topcoat can shift this balance.

Precoat	1	2	3
GCC 60<2µm (C60)	100	75	75
Brazilian Coarse Plately BR-CP		25	25
Target coatweight (gsm)	9.0	9.0	9.0
Topcoat	1	2	3
GCC 99	60	60	60
GCC 60	40	40	20
Brazilian Coarse Plately BR-CP			20
SB Latex	10	10	10
Immobiliser	0.1	0.1	0.1
Lubricant	0.8	0.8	0.8
Thickener	0.2	0.2	0.2
Application solids (wt%)	70	70	70
Coatweight gsm	11	11	11

- Precoat kaolins can also be used to good effect in Matt/Silk Topcoating to replace coarse GCC.

## MULTILAYER COATING CONCEPTS: IS IT TIME FOR A NEW APPROACH?

### MOTTLE CONSIDERATIONS

Mottle is one of the most common problems reported for coated papers and often occurs because of differences in porosity in the coating layers or poor coverage of base paper. It follows that improving coverage in the precoat could be a powerful tool for reducing mottling tendency whether this be an optical type mottle on lower brightness basestocks or a gloss or print mottle.

In the following example the influence of the precoat on optical mottle tendency was explored using whitelined chipboard with a PPS 10 roughness of 5.2m. In this case, 25 parts of high shape kaolin were added to a precoat recipe based on 60 grade GCC. A latex-starch recipe was used and colour solids of 66.5% were maintained throughout. Precoating was carried out at pilot scale and topcoating using a laboratory Helicoater™. A standard top coat based on 95 grade GCC and 15 parts of glossing kaolin was applied and compared with another based on 100% ultrafine GCC.

Optical maps were generated using a computer scanner where greyscale images were collected and the variation assessed using image analysis techniques. The were lightly calendered to achieve a target gloss of approximately 40. The results show that using coarse high-shape kaolin in the precoat improved smoothness for the same paper gloss level and improved print gloss development (delta gloss) without adverse changes in ink setting. Significant improvements in delta gloss, print abrasion (ink scuff), and opacity resulted when the same coarse kaolin was used to partially replace the coarse carbonate in the bimodal low gloss top coat. Paper gloss and ink setting rates were similar to those of the all carbonate reference. Overall, adding coarse platey kaolin to the precoat provides low sheet roughness for a given target gloss, which helps with print gloss development. These kaolins also improve printability when used in the top coat.

### INFLUENCE OF PRECOAT IN MATT/SILK WOOD-FREE

Producing a good matt or silk paper is really about finding the best compromise between often competing paper characteristics. Producers of matt and silk papers strive for good smoothness, low paper gloss, high bulk, and high print snap or delta gloss without overly slow ink setting. This latter issue, particularly in low gloss papers, can cause ink scuff problems and printing press inefficiencies.

To see if modifying the precoat can influence the gloss-smoothness balance in low gloss applications and improve delta gloss without slowing ink setting rates, pilot coated base papers based on 100% 60 grade GCC and 60 grade GCC with 25% coarse platey Brazilian kaolin were used to map these effects. In addition to applying a standard kaolin-free bimodal top coat, some of the coarse carbonate used to control gloss in the top coat was replaced with the same high shape kaolin used in the precoat. The coated papers were lightly calendered to achieve a target gloss of approximately 40.



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Overall, adding coarse platey kaolin to the precoat provides low sheet roughness for a given target gloss, which helps with print gloss development. These kaolins also improve printability when used in the top coat.

### CONCLUSIONS

In today's fine paper environment it can be advantageous to use the functionality of kaolin in precoating rather than in topcoating to achieve superior basepaper coverage with increased bulk and light scatter.

Good base paper coverage is essential in maintaining quality in multilayer coating applications and can reduce costs. Combining kaolin and coarse carbonate can enhance the ability of the precoat to cover base coat roughness which could enable the use of lower cost rougher base stocks without the same tendency for mottle related issues. Improved precoat coverage can facilitate the use of kaolin-free top coats, especially on rougher base stocks, reducing the need for high-cost ultrafine glossing kaolin and offering potential for top coat binder reduction. Kaolin in precoating also improves print reducing the need for more expensive binders to control printability. Additionally, coarse platey kaolin in the precoat helps smoothness and delta gloss in matt or silk grades, with further benefits coming from using the same kaolin to replace some coarse GCC in the top coat.

Overall it is evident that while carbonates can be made fine enough to deliver gloss they cannot be modified sufficiently in shape to improve coverage. As a result, we conclude that the value of kaolin in today's cost focussed coated fine paper market is therefore in its ability to cover the surface, not in its ability to generate paper gloss. 🌐